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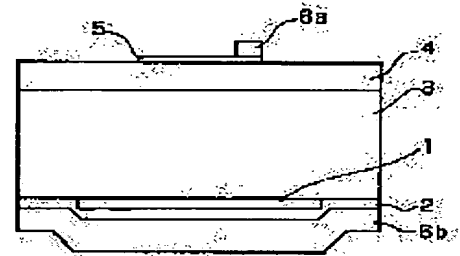
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(54) NITRIDE SEMICONDUCTOR LIGHT-EMITTING DIODE

(57)Abstract:

PROBLEM TO BE SOLVED: To improve efficiency of an LED by reflecting the light outputted to a substrate side, in a nitride semiconductor LED using a semiconductor substrate of SiC or GaN, which are satisfactory in crystallinity and thermal conductivity, and have transparency with respect to the output light of the LED.

SOLUTION: This nitride semiconductor LED has a nitride semiconductor LED structure 4 disposed on a semiconductor substrate 3. The rear of the substrate 3, which is the side opposite to a light extracting side, in a part just below a P-type electrode 5 on the light outputting side is covered with laminated structure of a transparent insulation layer 1 and an N-type electrode 2.



- 1...透明絶縁膜
- 2...n型電極
- 3...半導体基板
- 4...窒化物半導体LED構造
- 5...p型電極
- 5a...p型電極(トップ電極)
- 6b...n型電極

図1

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CLAIMS

[Claim(s)]

[Claim 1] Nitride semi-conductor light emitting diode characterized by covering said substrate rear face of the said optical ejection side and opposite hand of the part directly under an electrode by the side of optical ejection with the laminated structure of a transparence insulating layer and a metal layer at least in the nitride semi-conductor light emitting diode which has the luminous layer which consists of a nitride semi-conductor formed on the semi-conductor substrate.

[Claim 2] Nitride semi-conductor light emitting diode according to claim 1 characterized by using a gallium nitride substrate or a silicon carbide substrate as said substrate.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the nitride semi-conductor light emitting diode which has the luminous layer which consists of a nitride semi-conductor formed on the semi-conductor substrate.

[0002]

[Description of the Prior Art] The former, light emitting diode (Light Emitting Diode.) Hereafter, LED is called. LED which consists of a nitride semi-conductor has so far been formed mainly on silicon on sapphire inside.

[0003] However, on silicon on sapphire, since the rearrangement of a high consistency called 10^9 – 10^{10} cm⁻² in dislocation density existed in a luminous layer even when forming a thick buffer layer with a thickness of about 4 micrometers or more it is thin from a nitride in an elevated temperature and forming a crystalline nucleus in low temperature, it was difficult to improve the property of LED.

[0004] On the other hand, when forming a nitride semi-conductor layer on a SiC (silicon carbide) substrate The inequality (namely, grid mismatching) of a crystal lattice is very small as compared with 3.4% and about 13% at the time of forming a nitride semi-conductor layer on silicon on sapphire. Moreover, in a field vertical to c shaft orientations of method ** of six which are the main growth directions of a nitride semi-conductor layer, it has a polar side. From there being no imperfection of the surface treatment in the growth early stages of a nitride semi-conductor layer, very thin component [in other words] production by the more nearly quality nitride semi-conductor layer at a very high throughput is possible. For example, even when forming a thin buffer layer with a thickness of about 0.5 micrometers by short growth time amount, the growth with as quality dislocation density as [about 10^8 cm⁻²] two is possible.

[0005] Furthermore, since the coefficient-of-thermal-expansion difference of the substrate and nitride semi-conductor layer which pose a problem with a SiC substrate will not arise while much more good crystal quality is acquired if the GaN (gallium nitride) substrate with which development is progressing in recent years is used, the degree of freedom of component-izing is improved remarkably.

[0006] Since conductivity can be given to a substrate by doping an impurity in a GaN substrate in these SiC(s) list unlike silicon on sapphire, there is the description that one electrode of LED can be formed in the rear face of a substrate.

[0007] Moreover, as compared with silicon on sapphire, these substrates have high thermal conductivity and may be able to control degradation of the mould resin which poses a problem by blue LED.

[0008] Furthermore, in these substrates, make high impurity concentration into necessary minimum, a substrate is ground, or it becomes possible using GaN or 4 H-SiC substrate etc. to consider as a comparatively transparent substrate to important blue luminescence in the nitride semi-conductor LED. Therefore, possibility of reflecting the light by which outgoing radiation was carried out to the substrate side, and taking out from a luminous layer arises.

[0009]

[Problem(s) to be Solved by the Invention] However, if the metal (titanium) excellent in ohmic nature, for example, Ti etc., is actually vapor-deposited at the substrate rear face in order to take an electrode from the rear face of a substrate, an optical absorption layer will be formed of the level produced in the interface of a semi-conductor substrate and an ohmic metal. For this reason, the light emitted to the substrate side from the luminous layer was absorbed by this interface, and had the technical problem that it could not take out outside.

[0010] The object of this invention is excellent in crystallinity and thermal conductivity, reflects efficiently the light which carried out outgoing radiation to the substrate side in the nitride semi-conductor LED using

semi-conductor substrates, such as SiC or GaN which has transparency to the outgoing radiation light of LED, and is to raise the optical ejection effectiveness of LED.

[0011]

[Means for Solving the Problem] In order to solve the above-mentioned technical problem, this invention is characterized by covering said substrate rear face of the said optical ejection side and opposite hand of the part directly under an electrode by the side of optical ejection with the laminated structure of a transparence insulating layer and a metal layer at least in the nitride semi-conductor LED which has the luminous layer which consists of a nitride semi-conductor formed on the semi-conductor substrate.

[0012] Moreover, it is characterized by using a gallium nitride substrate or a silicon carbide substrate as said substrate.

[0013] In this invention, by covering a substrate rear face with the laminated structure of a transparence insulating layer and a metal layer (substrate rear-face lateral electrode), conventionally, the optical absorption produced between the semi-conductor substrate and the substrate rear-face lateral electrode can be reduced, and the optical ejection effectiveness of LED can be raised.

[0014]

[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained to a detail using a drawing. In addition, with the drawing explained below, what has the same function attaches the same sign, and explanation of the repeat is omitted.

[0015] Gestalt 1 drawing 1 of operation is the side elevation showing the structure of LED of the gestalt 1 of operation of this invention.

[0016] The transparence or the translucent ohmic p mold electrode and the ohmic n mold electrode with which a transparence insulator layer and 2 consist of titanium with a thickness of 20nm in 1 with which, as for the semi-conductor substrate with which 3 consists of an n mold SiC, the LED structure where of 4 consists of a nitride semi-conductor and 5, nickel with a thickness of 10nm or nickel oxidized, p mold electrode for bondings with which 6a consists of gold with a thickness of 200nm, and 6b are n mold electrodes which consist of gold with a thickness of 200nm mostly.

[0017] That is, after washing 250 micrometers in thickness, and the substrate 3 which consists of n mold 6 H-SiC of doping concentration 10^{18}cm^{-3} by fluoric acid in an organic solvent list, the LED structure 4 which makes an InGa_N layer a luminous layer (graphic display abbreviation) by metal-organic chemical vapor deposition is produced. Thereby, electrical conductivity with a substrate 3 is securable for a buffer layer (graphic display abbreviation) using the AlGa_N mixed-crystal layer of n mold.

[0018] A nickel layer with a thickness of 10nm is vapor-deposited on the top face of a substrate 3, and transparent p mold electrode 5 which consists of nickel of about 250-micrometer angle using a photolithography process is formed. Then, p mold electrode (pad electrode) 6a for bondings which consists of gold of 50-micrometer angle is prepared on this p mold electrode 5.

[0019] Then, when the glass plate was stuck on the top face of the direction in which p mold electrode 5 of this substrate 3 was formed, the rear face was ground and thickness of a substrate 3 was made thin with 70 micrometers, the color of a substrate 3 changed to the almost transparent color from the light green color.

[0020] After washing this substrate 3, SiO₂ film is formed in that rear face about 100nm in thickness. Then, using a photolithography process, the other SiO₂ film is removed and the transparence insulator layer 1 which consists of SiO₂ is formed so that the pattern of SiO₂ film of about 350-micrometer angle may be formed focusing on the part [directly under] of p mold electrode 5.

[0021] Then, on the rear face of the substrate 3 of the side in which the transparence insulator layer 1 was formed, Ti is vapor-deposited 20nm in thickness, n mold electrode 2 which functions also as reflective film (mirror) is formed, on it, Au is vapor-deposited 200nm in thickness, and n mold electrode 6b is formed.

[0022] Here, if this LED is seen from the top-face side in which p mold electrode 5 was formed, the part of n mold electrode 2 in which the part without the SiO₂ transparence insulator layer 1 carried out ohmic contact is carrying out the black color. That is, although this part absorbs light, a mirror with the bluish silver gloss is formed in the part which formed the SiO₂ transparence insulator layer 1.

[0023] After forming the above-mentioned n mold electrode 2 of the rear face of a substrate 3, and n mold electrode 6b, the above-mentioned glass plate is removed. If it energizes to this LED from p mold electrode 6a and n mold electrode 6b, an electron and an electron hole will recombine in the luminous layer of the LED structure 4, and light will be emitted. Although component resistance became a little high as compared with LED which does not form the SiO₂ transparence insulator layer 1 in LED of the gestalt 1 of this operation which formed the SiO₂ transparence insulator layer 1, optical ejection effectiveness has been improved about 50%.

[0024] With the gestalt 2 of two gestalten operation of operation, it is the example which applied this invention to the nitride semi-conductor LED on 4 H-SiC substrate. Component structure is the same with having been shown in drawing 1 R> 1.

[0025] The transparence or the translucent ohmic p mold electrode and the ohmic n mold electrode with which a transparence insulator layer and 2 consist of titanium with a thickness of 20nm in 1 with which, as for the semi-conductor substrate with which 3 consists of an n mold SiC, the LED structure where of 4 consists of a nitride semi-conductor and 5, nickel with a thickness of 10nm or nickel oxidized, p mold electrode for bondings with which 6a consists of gold with a thickness of 200nm, and 6b are n mold electrodes which consist of gold with a thickness of 200nm mostly.

[0026] That is, after washing 250 micrometers in thickness, and the substrate 3 which consists of n mold 4 H-SiC of doping concentration 10^{18}cm^{-3} by fluoric acid in an organic solvent list, the LED structure 4 which makes an InGaN layer a luminous layer (graphic display abbreviation) by metal-organic chemical vapor deposition is produced. Thereby, electrical conductivity with a substrate 3 is securable for a buffer layer (graphic display abbreviation) using the AlGaN mixed-crystal layer of n mold.

[0027] A nickel layer with a thickness of 10nm is vapor-deposited on the top face of a substrate 3, and transparent p mold electrode 5 which consists of nickel of about 250-micrometer angle using a photolithography process is formed. Then, p mold electrode 6a for bondings which consists of gold of 50-micrometer angle is prepared on this p mold electrode 5.

[0028] Then, a glass plate is stuck on the top face of the direction in which p mold electrode 5 of this substrate 3 was formed, a rear face is ground, and thickness of a substrate 3 is made thin with 100 micrometers. Since 4 H-SiC substrate had good transparency as compared with 6 H-SiC substrate, it became a substrate with transparent about 100 micrometers even in thickness.

[0029] After washing this substrate 3, SiO₂ film is formed in that rear face about 100nm in thickness. Then, using a photolithography process, the other SiO₂ film is removed and the transparence insulator layer 1 which consists of SiO₂ is formed so that the pattern of SiO₂ film of about 350-micrometer angle may be formed focusing on the part [directly under] of p mold electrode 5.

[0030] Then, on the rear face of the substrate 3 of the side in which the transparence insulator layer 1 was formed, Ti is vapor-deposited 20nm in thickness, n mold electrode 2 which functions also as reflective film (mirror) is formed, on it, Au is vapor-deposited 200nm in thickness, and n mold electrode 6b is formed.

[0031] Here, if this LED is seen from the top-face side in which p mold electrode 5 was formed, the part of n mold electrode 2 in which the part without the SiO₂ transparence insulator layer 1 carried out ohmic contact is carrying out the black color. That is, although this part absorbs light, a mirror with the bluish silver gloss is formed in the part which formed the SiO₂ transparence insulator layer 1.

[0032] After forming the above-mentioned n mold electrode 2 of the rear face of a substrate 3, and n mold electrode 6b, the above-mentioned glass plate is removed. If it energizes to this LED from p mold electrode 6a and n mold electrode 6b, an electron and an electron hole will recombine in the luminous layer of the LED structure 4, and light will be emitted. 4 H-SiC substrate had good conductivity, and since the comparatively thick substrate could be used, optical ejection effectiveness has been improved about 50% at LED of the gestalt 2 of this operation which formed the SiO₂ transparence insulator layer 1 by component resistance equivalent to LED which does not form the SiO₂ transparence insulator layer 1.

[0033] With the gestalt 3 of three gestalten operation of operation, it is the example which applied this invention to the nitride semi-conductor LED on a GaN substrate. Component structure is the same with having been shown in drawing 1 .

[0034] The transparence or the translucent ohmic p mold electrode and the ohmic n mold electrode with which a transparence insulator layer and 2 consist of aluminum with a thickness of 20nm in 1 with which, as for the semi-conductor substrate with which 3 consists of an n mold GaN, the LED structure where of 4 consists of a nitride semi-conductor and 5, nickel with a thickness of 10nm or nickel oxidized, p mold electrode for bondings with which 6a consists of gold with a thickness of 200nm, and 6b are n mold electrodes which consist of gold with a thickness of 200nm mostly.

[0035] That is, after a hydrochloric acid washes 400 micrometers in thickness, and the substrate 3 which consists of an n mold GaN of doping concentration $5 \times 10^{18}\text{cm}^{-3}$ in an organic solvent list, the LED structure 4 which makes an InGaN layer a luminous layer (graphic display abbreviation) by metal-organic chemical vapor deposition is produced. Thereby, electrical conductivity with a substrate 3 is securable for a buffer layer (graphic display abbreviation) using the GaN layer of n mold.

[0036] A nickel layer with a thickness of 10nm is vapor-deposited on the top face of a substrate 3, and transparent p mold electrode 5 which consists of nickel of about 250-micrometer angle using a photolithography process is formed. Then, p mold electrode 6a for bondings which consists of gold of 50-

micrometer angle is prepared on this p mold electrode 5.

[0037] Since a GaN substrate has a large band gap as compared with 4 H-SiC substrate or 6 H-SiC substrate and transparency is very good, it is a substrate even with transparent 400-micrometer Noma in thickness. Therefore, polish of a substrate 3 is not performed like the gestalten 1 and 2 of operation.

[0038] After washing this substrate 3, SiO₂ film is formed in that rear face about 100nm in thickness. Then, using a photolithography process, the other SiO₂ film is removed and the transparence insulator layer 1 which consists of SiO₂ is formed so that the pattern of SiO₂ film of about 350-micrometer angle may be formed focusing on the part [directly under] of p mold electrode 5.

[0039] Then, on the rear face of the substrate 3 of the side in which the transparence insulator layer 1 was formed, aluminum is vapor-deposited 20nm in thickness, n mold electrode 2 which functions also as reflective film (mirror) is formed, on it, Au is vapor-deposited 200nm in thickness, and n mold electrode 6b is formed.

[0040] Here, if this LED is seen from the top-face side in which p mold electrode 5 was formed, the part of n mold electrode 2 in which the part without the SiO₂ transparence insulator layer 1 carried out ohmic contact is carrying out the black color. That is, although this part absorbs light, a mirror with the bluish silver gloss is formed in the part which formed the SiO₂ transparence insulator layer 1.

[0041] If it energizes to this LED from p mold electrode 6a and n mold electrode 6b, an electron and an electron hole will recombine in the luminous layer of the LED structure 4, and light will be emitted. The GaN substrate had good conductivity, and since the comparatively thick substrate could be used, optical ejection effectiveness has been improved about 50% at LED of the gestalt 3 of this operation which formed the SiO₂ transparence insulator layer 1 by component resistance equivalent to LED which does not form the SiO₂ transparence insulator layer 1.

[0042] With the gestalt 3 of four gestalten operation of operation, it is the example which applied this invention to the nitride semi-conductor LED on a GaN substrate.

[0043] Drawing 2 is the side elevation showing the structure of LED of the gestalt 4 of operation of this invention.

[0044] The transparence or the translucent ohmic p mold electrode and the ohmic n mold electrode with which a transparence insulator layer and 2 consist of aluminum with a thickness of 20nm in 1 with which, as for the semi-conductor substrate with which 3 consists of an n mold GaN, the LED structure where of 4 consists of a nitride semi-conductor and 5, nickel with a thickness of 10nm or nickel oxidized, p mold electrode for bondings with which 6a consists of gold with a thickness of 200nm, and 6b are n mold electrodes which consist of gold with a thickness of 200nm mostly.

[0045] That is, after a hydrochloric acid washes 400 micrometers in thickness, and the substrate 3 which consists of an n mold GaN of doping concentration $5 \times 10^{18} \text{cm}^{-3}$ in an organic solvent list, the LED structure 4 which makes an InGa_N layer a luminous layer (graphic display abbreviation) by metal-organic chemical vapor deposition is produced. Thereby, electrical conductivity with a substrate 3 is securable for a buffer layer (graphic display abbreviation) using the GaN layer of n mold.

[0046] A nickel layer with a thickness of 10nm is vapor-deposited on the top face of a substrate 3, and transparent p mold electrode 5 which consists of nickel of about 250-micrometer angle using a photolithography process is formed. Then, p mold electrode 6a for bondings which consists of gold of 50-micrometer angle is prepared on this p mold electrode 5.

[0047] Since a GaN substrate has a large band gap as compared with 4 H-SiC substrate or 6 H-SiC substrate and transparency is very good, it is a substrate even with transparent 400-micrometer Noma in thickness. Therefore, polish of a substrate 3 is not performed like the gestalten 1 and 2 of operation.

[0048] After washing this substrate 3, the silicon resin film (for example, Tokyo adaptation make OCD) is dropped at the part [directly under] of p mold electrode 5 of that rear face. Then, the transparence insulator layer 1 which heats this silicon resin film at 350 degrees C for 4 hours, burns in the shape of a dome, and consists of hammer hardening and SiO₂ film is formed. The magnitude is 350 micrometers in diameter about focusing on the part [directly under] of p mold electrode 5.

[0049] Then, on the rear face of the substrate 3 of the side in which the transparence insulator layer 1 was formed, aluminum is vapor-deposited 20nm in thickness, n mold electrode 2 which functions also as reflective film (mirror) is formed, on it, Au is vapor-deposited 200nm in thickness, and n mold electrode 6b is formed.

[0050] Here, if this LED is seen from the top-face side in which p mold electrode 5 was formed, the part of n mold electrode 2 in which the part without the SiO₂ transparence insulator layer 1 carried out ohmic contact is carrying out the black color. That is, although this part absorbs light, the mirror which has the interference color is formed in the part which formed the SiO₂ transparence insulator layer 1.

[0051] If it energizes to this LED from p mold electrode 6a and n mold electrode 6b, an electron and an electron hole will recombine in the luminous layer of the LED structure 4, and light will be emitted. The GaN substrate had good conductivity, and since the comparatively thick substrate could be used, optical ejection effectiveness has been improved about 60% at LED of the gestalt 4 of this operation which formed the SiO₂ transparence insulator layer 1 by component resistance equivalent to LED which does not form the SiO₂ transparence insulator layer 1. This reason is because the light of the include angle which originally cannot carry out outgoing radiation on the outside of an escape cone (escape-cone) can also be taken out by having formed the SiO₂ transparence insulator layer 1 of the rear face of a substrate 3 in the shape of a dome, and having formed the spherical-surface mirror.

[0052] It is the example which applied this invention to the nitride semi-conductor LED which has p mold electrode of a tandem-type pattern with the gestalt 5 of five gestalten operation of operation.

[0053] The plan in which drawing 3 (a) shows the structure of LED of the gestalt 5 of operation of this invention, and (b) are side elevations.

[0054] The transparence or the translucent ohmic p mold electrode and the ohmic n mold electrode with which a transparence insulator layer and 2 consist of titanium with a thickness of 20nm in 1 with which, as for the semi-conductor substrate with which 3 consists of an n mold SiC, the LED structure where of 4 consists of a nitride semi-conductor and 5, nickel with a thickness of 10nm or nickel oxidized, p mold electrode for bondings with which 6a consists of gold with a thickness of 200nm, and 6b are n mold electrodes which consist of gold with a thickness of 200nm mostly.

[0055] That is, after washing 250 micrometers in thickness, and the substrate 3 which consists of n mold 6 H-SiC of doping concentration 10^{18}cm^{-3} by fluoric acid in an organic solvent list, the LED structure 4 which makes an InGaN layer a luminous layer (graphic display abbreviation) by metal-organic chemical vapor deposition is produced. Thereby, electrical conductivity with a substrate 3 is securable for a buffer layer (graphic display abbreviation) using the AlGaN mixed-crystal layer of n mold.

[0056] Almost transparent p mold electrode 5 of a tandem type with which the nickel layer of the shape of seven stripe was connected as a nickel layer with a thickness of 10nm was vapor-deposited on the top face of a substrate 3 and it was shown in the field of about 300-micrometer angle at drawing 3 (a) using a photolithography process is formed. Then, p mold electrode 6a for bondings which consists of gold of 50-micrometer angle is prepared on this p mold electrode 5.

[0057] Then, when the glass plate was stuck on the top face of the direction in which p mold electrode 5 of this substrate 3 was formed, the rear face was ground and thickness of a substrate 3 was made thin with 70 micrometers, the color of a substrate 3 changed to the almost transparent color from the light green color.

[0058] After washing this substrate 3, SiO₂ film is formed in that rear face about 100nm in thickness. Then, using a photolithography process, the other SiO₂ film is removed and the transparence insulator layer 1 which consists of SiO₂ is formed so that the pattern of SiO₂ film of about 350-micrometer angle may be formed focusing on the part [directly under] of p mold electrode 5.

[0059] Then, on the rear face of the substrate 3 of the side in which the transparence insulator layer 1 was formed, Ti is vapor-deposited 20nm in thickness, n mold electrode 2 which functions also as reflective film (mirror) is formed, on it, Au is vapor-deposited 200nm in thickness, and n mold electrode 6b is formed.

[0060] Here, if this LED is seen from the top-face side in which p mold electrode 5 was formed, the part of n mold electrode 2 in which the part without the SiO₂ transparence insulator layer 1 carried out ohmic contact is carrying out the black color. That is, although this part absorbs light, a mirror with the bluish silver gloss is formed in the part which formed the SiO₂ transparence insulator layer 1.

[0061] After forming the above-mentioned n mold electrode 2 of the rear face of a substrate 3, and n mold electrode 6b, the above-mentioned glass plate is removed. If it energizes to this LED from p mold electrode 6a and n mold electrode 6b, an electron and an electron hole will recombine in the luminous layer of the LED structure 4, and light will be emitted. Although component resistance became a little high as compared with LED which does not form the SiO₂ transparence insulator layer 1 in LED of the gestalt 5 of this operation which formed the SiO₂ transparence insulator layer 1, optical ejection effectiveness has been improved about 60%. As compared with the optical ejection effectiveness of LED of the gestalt 1 of operation being 50%, the optical ejection effectiveness of the gestalt 5 of this operation is because p mold electrode 5 with almost transparent 60% and high thing was formed in the tandem type. That is, it is because the optical absorption in the ohmic contact section of the interface of a substrate 3 and p mold electrode 5 decreases by having formed the ohmic p mold electrode 5 in the tandem type among luminescence reflected by the interface of the transparence insulator layer 1 of the rear face of a substrate 3, and n mold electrode 2.

[0062] As mentioned above, in the nitride semi-conductor LED which has the luminous layer which consists of a nitride semi-conductor formed on the semi-conductor substrate 3, the laminated structure with n mold electrode 2 of the transparence insulating layer 1 and a metal layer covered substrate 3 rear face of the optical ejection side and opposite hand of the part [directly under] of p mold electrode 5 by the side of optical ejection with the gestalten 1-5 of the above-mentioned implementation. Since the optical absorption produced between the semi-conductor substrate 3 and the substrate rear-face side n mold electrode 2 can be conventionally reduced by this configuration, the optical ejection effectiveness of LED can be raised.

[0063] Although this invention was concretely explained based on the gestalt of operation above, as for this invention, it is needless to say for it to be able to change variously in the range which is not limited to the gestalt of the above-mentioned implementation and does not deviate from the summary. For example, although the gestalt of the above-mentioned implementation showed the example of the easy LED structure for explanation, when considering as actual optical components, it is possible by forming resin in the outgoing radiation side 5, i.e., p mold electrode, side of light in the shape of a dome to obtain luminescence which bleedoff light of LED was refracted on this dome front face, and was excellent in directivity. Moreover, it is possible to reflect in a longitudinal direction upward the light which carried out outgoing radiation with a concave mirror from LED, and to realize LED with optical, more high ejection effectiveness by using for the perimeter of LED the frame which has a concave mirror. Of course, it cannot be overemphasized by sharing dome-like resin and a concave mirror that LED which was further excellent in outgoing radiation directional control and optical ejection effectiveness is realizable. Moreover, although resin may be stiffened on the metal base material which mounts an LED chip, it cannot be overemphasized that the structure which carried out the mould of the resin by dipping, and enclosed the metal base material by resin is also applicable. Moreover, it is also easy to form the film which is made to contain the fluorescence ingredient which emits the light, or contains a fluorescence ingredient on the underside of resin, medium, and the top face into the resin which covers the ultraviolet-rays luminescence LED, and to realize LED with luminescence wavelength distribution larger than white etc. Furthermore, it cannot be overemphasized that the electrode structure with much irregularity of reducing the optical absorption in the ohmic contact section is applicable like the tandem-type electrode of the gestalt 5 of operation shown in drawing 3 (a).

[0064]

[Effect of the Invention] Since the optical absorption produced between the semi-conductor substrate and the substrate rear-face lateral electrode can be conventionally reduced according to this invention as explained above, LED which was excellent in optical ejection effectiveness is realizable.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the side elevation showing the structure of LED of the gestalten 1-3 of operation of this invention.

[Drawing 2] It is the side elevation showing the structure of LED of the gestalt 4 of operation of this invention.

[Drawing 3] The plan in which (a) shows the structure of LED of the gestalt 5 of operation of this invention, and (b) are side elevations.

[Description of Notations]

1 [-- Nitride semi-conductor LED structure, 5 / -- p mold electrode, 6 a--p mold electrodes (pad electrode), 6 b--n mold electrodes.] -- A transparence insulator layer, 2 -- n mold electrode, 3 -- A semi-conductor substrate, 4

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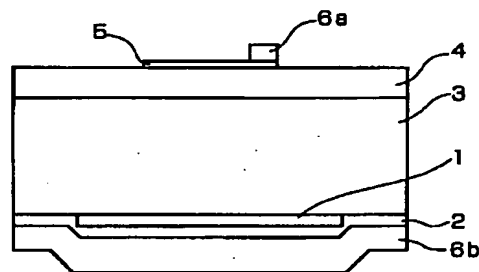
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(54) 【発明の名称】 窒化物半導体発光ダイオード

(57) 【要約】

【課題】 結晶性、熱伝導性に優れ、LEDの出射光に対して透明性を有するSiCまたはGaN等の半導体基板を用いた窒化物半導体LEDにおいて、基板側に出射した光を効率良く反射させ、LEDの光取り出し効率を向上させる。

【解決手段】 半導体基板3上に設けた窒化物半導体LED構造4を有し、光取り出し側のp型電極5の直下の部分の、光取り出し側と反対側の基板3裏面を、透明絶縁層1と金属層のn型電極2との積層構造により被覆した窒化物半導体LED。



- 1...透明絶縁膜
- 2...n型電極
- 3...半導体基板
- 4...窒化物半導体LED構造
- 5...p型電極
- 6a...p型電極(パッド電極)
- 6b...n型電極

図 1

【特許請求の範囲】

【請求項1】半導体基板上に設けた窒化物半導体からなる発光層を有する窒化物半導体発光ダイオードにおいて、光取り出し側の少なくとも電極直下の部分の、前記光取り出し側と反対側の前記基板裏面を、透明絶縁層と金属層との積層構造により被覆したことを特徴とする窒化物半導体発光ダイオード。

【請求項2】前記基板として窒化ガリウム基板または炭化珪素基板を用いることを特徴とする請求項1記載の窒化物半導体発光ダイオード。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、半導体基板上に設けた窒化物半導体からなる発光層を有する窒化物半導体発光ダイオードに関する。

【0002】

【従来の技術】従来、発光ダイオード（Light Emitting Diode、以下、LEDと称する。）のうち、窒化物半導体からなるLEDは、これまで主としてサファイア基板上に形成されてきた。

【0003】しかしながら、サファイア基板上では、高温において窒化物からなる厚さ4 μ m程度以上の厚いバッファ層を形成し、低温において結晶核を形成する場合でも、転位密度が $10^8 \sim 10^{10} \text{ cm}^{-2}$ という高い密度の転位が発光層に存在するため、LEDの特性を向上することは困難であった。

【0004】これに対して、SiC（炭化珪素）基板上に窒化物半導体層を形成する場合は、結晶格子の不一致（すなわち、格子不整合）が3、4%と、サファイア基板上に窒化物半導体層を形成した場合の約13%に比較して大変小さく、また、窒化物半導体層の主な成長方向である6方晶のc軸方向に垂直な面において極性面を有し、窒化物半導体層の成長初期における表面改質の不完全性が無いことから、極めて薄い、言い換えれば極めて高いスループットでより高品質な窒化物半導体層による素子作製が可能となっている。例えば、短い成長時間で厚さ0.5 μ m程度の薄いバッファ層を形成する場合でも、転位密度が 10^8 cm^{-2} 程度と、高品質な成長が可能である。

【0005】さらに、近年開発の進んでいるGaN（窒化ガリウム）基板を用いると、一層良好な結晶品質が得られるとともに、SiC基板で問題となる基板と窒化物半導体層との熱膨張率差が生じないために、素子化の自由度が著しく改善される。

【0006】これら、SiC並びにGaN基板においては、サファイア基板と異なり、不純物のドーピングを施すことにより、基板に導電性を与えることができることから、LEDの一方の電極を基板の裏面に形成することができるという特徴がある。

【0007】また、これらの基板はサファイア基板と比

較して熱伝導率が高く、青色LEDで問題となるモールド樹脂の劣化を抑制できる可能性がある。

【0008】さらに、これらの基板では、不純物濃度を必要最低限にしたり、基板を研磨したり、GaNまたは4H-SiC基板を用いるなどにより、窒化物半導体LEDにおいて重要な青色発光に対し、比較的透明な基板とすることが可能となる。したがって、発光層から基板側に射出された光を反射させて取り出す可能性が生じる。

10 【0009】

【発明が解決しようとする課題】しかしながら、実際には、基板の裏面から電極を取るために、オーミック性に優れた金属、例えばTi（チタン）等を基板裏面に蒸着すると、半導体基板とオーミック金属との界面に生じる準位により光吸収層が形成されてしまう。このため、発光層から基板側に放出された光は、この界面で吸収され、外部に取り出すことができないという課題があった。

20 【0010】本発明の目的は、結晶性、熱伝導性に優れた、LEDの射出光に対して透明性を有するSiCまたはGaN等の半導体基板を用いた窒化物半導体LEDにおいて、基板側に射出した光を効率良く反射させ、LEDの光取り出し効率を向上させることにある。

【0011】

【課題を解決するための手段】上記課題を解決するために、本発明は、半導体基板上に設けた窒化物半導体からなる発光層を有する窒化物半導体LEDにおいて、光取り出し側の少なくとも電極直下の部分の、前記光取り出し側と反対側の前記基板裏面を、透明絶縁層と金属層との積層構造により被覆したことを特徴とする。

30 【0012】また、前記基板として窒化ガリウム基板または炭化珪素基板を用いることを特徴とする。

【0013】本発明では、基板裏面を透明絶縁層と金属層（基板裏面側電極）との積層構造で被覆することにより、従来、半導体基板と基板裏面側電極との間で生じた光吸収を低減することができ、LEDの光取り出し効率を向上させることができる。

【0014】

40 【発明の実施の形態】以下、図面を用いて本発明の実施の形態について詳細に説明する。なお、以下で説明する図面で、同一機能を有するものは同一符号を付け、その繰り返しの説明は省略する。

【0015】実施の形態1

図1は、本発明の実施の形態1のLEDの構造を示す側面図である。

【0016】3はn型SiCからなる半導体基板、4は窒化物半導体からなるLED構造、5は厚さ10nmのニッケルまたはニッケルが酸化したほぼ透明または半透明オーミックp型電極、1は透明絶縁膜、2は厚さ20nmのチタンからなるオーミックn型電極、6aは厚さ

200nmの金からなるボンディング用p型電極、6bは厚さ200nmの金からなるn型電極である。

【0017】すなわち、厚さ250 μ m、ドーピング濃度 10^{18} cm $^{-3}$ のn型6H-SiCからなる基板3を有機溶剤並びにフッ酸で洗浄した後、有機金属気相成長法によりInGa N 層を発光層(図示省略)とするLED構造4を作製する。バッファ層(図示省略)にはn型のAlGa N 混晶層を用い、これにより基板3との電気伝導性が確保できる。

【0018】基板3の上面に厚さ10nmのニッケル層を蒸着し、フォトリソグラフィ・プロセスを用いておよそ250 μ m角のニッケルからなる透明なp型電極5を形成する。その後、このp型電極5の上に、50 μ m角の金からなるボンディング用p型電極(パッド電極)6aを設ける。

【0019】その後、この基板3のp型電極5を形成した方の上面にガラス板を貼り付け、裏面を研磨し、基板3の厚さを70 μ mと薄くしたところ、基板3の色は薄緑色からほとんど透明な色に変わった。

【0020】この基板3を洗浄した後、その裏面にSiO $_2$ 膜を厚さ100nm程度形成する。その後、フォトリソグラフィ・プロセスを用い、p型電極5の直下の部分を中心におよそ350 μ m角のSiO $_2$ 膜のパターンを形成するように、それ以外のSiO $_2$ 膜を除去し、SiO $_2$ からなる透明絶縁膜1を形成する。

【0021】その後、透明絶縁膜1を形成した側の基板3の裏面上にTiを厚さ20nm蒸着し、反射膜(ミラー)としても機能するn型電極2を形成し、その上にAuを厚さ200nm蒸着して、n型電極6bを形成する。

【0022】ここで、このLEDをp型電極5を設けた上面側から見ると、SiO $_2$ 透明絶縁膜1の無い部分のオーミック接触したn型電極2の部分は黒い色をしている。すなわち、この部分は光を吸収するが、SiO $_2$ 透明絶縁膜1を設けた部分では、青みがかった銀色の光沢をもった鏡が形成される。

【0023】基板3の裏面の上記n型電極2、n型電極6bを形成した後、上記ガラス板を取り除く。このLEDにp型電極6a、n型電極6bから通電すると、LED構造4の発光層において電子と正孔とが再結合し、光が放出される。SiO $_2$ 透明絶縁膜1を設けた本実施の形態1のLEDでは、SiO $_2$ 透明絶縁膜1を設けないLEDと比較して素子抵抗がやや高くなったが、光取り出し効率が約50%改善された。

【0024】実施の形態2

本実施の形態2では、本発明を4H-SiC基板上の窒化物半導体LEDに適用した例である。素子構造は、図1に示したのと同様である。

【0025】3はn型SiCからなる半導体基板、4は窒化物半導体からなるLED構造、5は厚さ10nmの

ニッケルまたはニッケルが酸化したほぼ透明または半透明オーミックp型電極、1は透明絶縁膜、2は厚さ20nmのチタンからなるオーミックn型電極、6aは厚さ200nmの金からなるボンディング用p型電極、6bは厚さ200nmの金からなるn型電極である。

【0026】すなわち、厚さ250 μ m、ドーピング濃度 10^{18} cm $^{-3}$ のn型4H-SiCからなる基板3を有機溶剤並びにフッ酸で洗浄した後、有機金属気相成長法によりInGa N 層を発光層(図示省略)とするLED構造4を作製する。バッファ層(図示省略)にはn型のAlGa N 混晶層を用い、これにより基板3との電気伝導性が確保できる。

【0027】基板3の上面に厚さ10nmのニッケル層を蒸着し、フォトリソグラフィ・プロセスを用いておよそ250 μ m角のニッケルからなる透明なp型電極5を形成する。その後、このp型電極5の上に、50 μ m角の金からなるボンディング用p型電極6aを設ける。

【0028】その後、この基板3のp型電極5を形成した方の上面にガラス板を貼り付け、裏面を研磨し、基板3の厚さを100 μ mと薄くする。4H-SiC基板は6H-SiC基板に比較して透明性が良いので、厚さ100 μ m程度でも透明な基板となった。

【0029】この基板3を洗浄した後、その裏面にSiO $_2$ 膜を厚さ100nm程度形成する。その後、フォトリソグラフィ・プロセスを用い、p型電極5の直下の部分を中心におよそ350 μ m角のSiO $_2$ 膜のパターンを形成するように、それ以外のSiO $_2$ 膜を除去し、SiO $_2$ からなる透明絶縁膜1を形成する。

【0030】その後、透明絶縁膜1を形成した側の基板3の裏面上にTiを厚さ20nm蒸着し、反射膜(ミラー)としても機能するn型電極2を形成し、その上にAuを厚さ200nm蒸着して、n型電極6bを形成する。

【0031】ここで、このLEDをp型電極5を設けた上面側から見ると、SiO $_2$ 透明絶縁膜1の無い部分のオーミック接触したn型電極2の部分は黒い色をしている。すなわち、この部分は光を吸収するが、SiO $_2$ 透明絶縁膜1を設けた部分では、青みがかった銀色の光沢をもった鏡が形成される。

【0032】基板3の裏面の上記n型電極2、n型電極6bを形成した後、上記ガラス板を取り除く。このLEDにp型電極6a、n型電極6bから通電すると、LED構造4の発光層において電子と正孔とが再結合し、光が放出される。4H-SiC基板は導電性が良く、比較的厚い基板でよいので、SiO $_2$ 透明絶縁膜1を設けた本実施の形態2のLEDでは、SiO $_2$ 透明絶縁膜1を設けないLEDと同等の素子抵抗で、光取り出し効率が約50%改善された。

【0033】実施の形態3

本実施の形態3では、本発明をGa N 基板上の窒化物半

導体LEDに適用した例である。素子構造は、図1に示したのと同様である。

【0034】3はn型GaNからなる半導体基板、4は窒化物半導体からなるLED構造、5は厚さ10nmのニッケルまたはニッケルが酸化したほぼ透明または半透明オーミックp型電極、1は透明絶縁膜、2は厚さ20nmのアルミニウムからなるオーミックn型電極、6aは厚さ200nmの金からなるボンディング用p型電極、6bは厚さ200nmの金からなるn型電極である。

【0035】すなわち、厚さ400 μ m、ドーピング濃度 $5 \times 10^{18} \text{ cm}^{-3}$ のn型GaNからなる基板3を有機溶剤並びに塩酸で洗浄した後、有機金属気相成長法によりInGaN層を発光層(図示省略)とするLED構造4を作製する。バッファ層(図示省略)にはn型のGaN層を用い、これにより基板3との電気伝導性が確保できる。

【0036】基板3の上面に厚さ10nmのニッケル層を蒸着し、フォトリソグラフィ・プロセスを用いておよそ250 μ m角のニッケルからなる透明なp型電極5を形成する。その後、このp型電極5の上に、50 μ m角の金からなるボンディング用p型電極6aを設ける。

【0037】GaN基板は4H-SiC基板や6H-SiC基板に比較してバンドギャップが大きく、透明性が大変良いので、厚さ400 μ m野間までも透明な基板である。したがって、実施の形態1、2のように基板3の研磨は行なわない。

【0038】この基板3を洗浄した後、その裏面にSiO₂膜を厚さ100nm程度形成する。その後、フォトリソグラフィ・プロセスを用い、p型電極5の直下の部分を中心におよそ350 μ m角のSiO₂膜のパターンを形成するように、それ以外のSiO₂膜を除去し、SiO₂からなる透明絶縁膜1を形成する。

【0039】その後、透明絶縁膜1を形成した側の基板3の裏面上にAlを厚さ20nm蒸着し、反射膜(ミラー)としても機能するn型電極2を形成し、その上にAuを厚さ200nm蒸着して、n型電極6bを形成する。

【0040】ここで、このLEDをp型電極5を設けた上面側から見ると、SiO₂透明絶縁膜1の無い部分のオーミック接触したn型電極2の部分は黒い色をしている。すなわち、この部分は光を吸収するが、SiO₂透明絶縁膜1を設けた部分では、青みがかった銀色の光沢をもった鏡が形成される。

【0041】このLEDにp型電極6a、n型電極6bから通電すると、LED構造4の発光層において電子と正孔とが再結合し、光が放出される。GaN基板は導電性が良く、比較的厚い基板でよいので、SiO₂透明絶縁膜1を設けた本実施の形態3のLEDでは、SiO₂透明絶縁膜1を設けないLEDと同等の素子抵抗で、光

取り出し効率が約50%改善された。

【0042】実施の形態4

本実施の形態3では、本発明をGaN基板上の窒化物半導体LEDに適用した例である。

【0043】図2は、本発明の実施の形態4のLEDの構造を示す側面図である。

【0044】3はn型GaNからなる半導体基板、4は窒化物半導体からなるLED構造、5は厚さ10nmのニッケルまたはニッケルが酸化したほぼ透明または半透明オーミックp型電極、1は透明絶縁膜、2は厚さ20nmのアルミニウムからなるオーミックn型電極、6aは厚さ200nmの金からなるボンディング用p型電極、6bは厚さ200nmの金からなるn型電極である。

【0045】すなわち、厚さ400 μ m、ドーピング濃度 $5 \times 10^{18} \text{ cm}^{-3}$ のn型GaNからなる基板3を有機溶剤並びに塩酸で洗浄した後、有機金属気相成長法によりInGaN層を発光層(図示省略)とするLED構造4を作製する。バッファ層(図示省略)にはn型のGaN層を用い、これにより基板3との電気伝導性が確保できる。

【0046】基板3の上面に厚さ10nmのニッケル層を蒸着し、フォトリソグラフィ・プロセスを用いておよそ250 μ m角のニッケルからなる透明なp型電極5を形成する。その後、このp型電極5の上に、50 μ m角の金からなるボンディング用p型電極6aを設ける。

【0047】GaN基板は4H-SiC基板や6H-SiC基板に比較してバンドギャップが大きく、透明性が大変良いので、厚さ400 μ m野間までも透明な基板である。したがって、実施の形態1、2のように基板3の研磨は行なわない。

【0048】この基板3を洗浄した後、その裏面のp型電極5の直下の部分にシリコン樹脂膜(例えば東京応化製OCD)を滴下する。その後、このシリコン樹脂膜を350℃で4時間加熱してドーム状に焼き固め、SiO₂膜からなる透明絶縁膜1を形成する。その大きさはp型電極5の直下の部分を中心におよそ直径350 μ mである。

【0049】その後、透明絶縁膜1を形成した側の基板3の裏面上にAlを厚さ20nm蒸着し、反射膜(ミラー)としても機能するn型電極2を形成し、その上にAuを厚さ200nm蒸着して、n型電極6bを形成する。

【0050】ここで、このLEDをp型電極5を設けた上面側から見ると、SiO₂透明絶縁膜1の無い部分のオーミック接触したn型電極2の部分は黒い色をしている。すなわち、この部分は光を吸収するが、SiO₂透明絶縁膜1を設けた部分では、干渉色を有する鏡が形成される。

【0051】このLEDにp型電極6a、n型電極6b

から通電すると、LED構造4の発光層において電子と正孔とが再結合し、光が放出される。Ga_{0.4}N基板は導電性が良く、比較的厚い基板でよいので、SiO₂透明絶縁膜1を設けた本実施の形態4のLEDでは、SiO₂透明絶縁膜1を設けないLEDと同等の素子抵抗で、光取り出し効率が約60%改善された。この理由は、基板3の裏面のSiO₂透明絶縁膜1をドーム状に形成して球面ミラーを形成したことにより、エスケープコーン (escape-cone) の外側で本来出射できない角度の光も取り出すことができるためである。

【0052】実施の形態5

本実施の形態5では、本発明を櫛型パターンのp型電極を有する窒化物半導体LEDに適用した例である。

【0053】図3(a)は、本発明の実施の形態5のLEDの構造を示す上面図、(b)は側面図である。

【0054】3はn型SiCからなる半導体基板、4は窒化物半導体からなるLED構造、5は厚さ10nmのニッケルまたはニッケルが酸化したほぼ透明または半透明オーミックp型電極、1は透明絶縁膜、2は厚さ20nmのチタンからなるオーミックn型電極、6aは厚さ200nmの金からなるボンディング用p型電極、6bは厚さ200nmの金からなるn型電極である。

【0055】すなわち、厚さ250μm、ドーピング濃度 10^{18} cm⁻³のn型6H-SiCからなる基板3を有機溶剤並びにフッ酸で洗浄した後、有機金属気相成長法によりInGa_{0.4}N層を発光層(図示省略)とするLED構造4を作製する。バッファ層(図示省略)にはn型のAlGa_{0.4}N混晶層を用い、これにより基板3との電気伝導性が確保できる。

【0056】基板3の上面に厚さ10nmのニッケル層を蒸着し、フォトリソグラフィ・プロセスを用いておよそ300μm角の領域に図3(a)に示すように例えば7本のストライプ状のニッケル層が連結された櫛型のほぼ透明なp型電極5を形成する。その後、このp型電極5の上に、50μm角の金からなるボンディング用p型電極6aを設ける。

【0057】その後、この基板3のp型電極5を形成した方の上面にガラス板を貼り付け、裏面を研磨し、基板3の厚さを70μmと薄くしたところ、基板3の色は薄緑色からほとんど透明な色に変わった。

【0058】この基板3を洗浄した後、その裏面にSiO₂膜を厚さ100nm程度形成する。その後、フォトリソグラフィ・プロセスを用い、p型電極5の直下の部分を中心におよそ350μm角のSiO₂膜のパターンを形成するように、それ以外のSiO₂膜を除去し、SiO₂からなる透明絶縁膜1を形成する。

【0059】その後、透明絶縁膜1を形成した側の基板3の裏面上にTiを厚さ20nm蒸着し、反射膜(ミラー)としても機能するn型電極2を形成し、その上にAuを厚さ200nm蒸着して、n型電極6bを形成す

る。

【0060】ここで、このLEDをp型電極5を設けた上面側から見ると、SiO₂透明絶縁膜1の無い部分のオーミック接触したn型電極2の部分は黒い色をしている。すなわち、この部分は光を吸収するが、SiO₂透明絶縁膜1を設けた部分では、青みがかった銀色の光沢をもった鏡が形成される。

【0061】基板3の裏面の上記n型電極2、n型電極6bを形成した後、上記ガラス板を取り除く。このLEDにp型電極6a、n型電極6bから通電すると、LED構造4の発光層において電子と正孔とが再結合し、光が放出される。SiO₂透明絶縁膜1を設けた本実施の形態5のLEDでは、SiO₂透明絶縁膜1を設けないLEDと比較して素子抵抗がやや高くなったが、光取り出し効率が約60%改善された。実施の形態1のLEDの光取り出し効率が50%であるのと比較して、本実施の形態5の光取り出し効率が60%と高いのは、ほぼ透明なp型電極5を櫛型に形成したからである。すなわち、基板3の裏面の透明絶縁膜1とn型電極2との界面で反射される発光のうち、オーミックp型電極5を櫛型に形成したことにより、基板3とp型電極5との界面のオーミック接触部での光吸収が低減するからである。

【0062】以上のように、上記実施の形態1~5では、半導体基板3上に設けた窒化物半導体からなる発光層を有する窒化物半導体LEDにおいて、光取り出し側のp型電極5の直下の部分の、光取り出し側と反対側の基板3裏面を、透明絶縁膜1と金属層のn型電極2との積層構造により被覆した。この構成により、従来、半導体基板3と基板裏面側n型電極2との間で生じた光吸収を低減できるので、LEDの光取り出し効率を向上させることができる。

【0063】以上本発明を実施の形態に基づいて具体的に説明したが、本発明は上記実施の形態に限定されるものではなく、その要旨を逸脱しない範囲において種々変更可能であることは勿論である。例えば、上記実施の形態では、説明のために簡単なLED構造の例を示したが、実際の光部品とする場合には、光の出射面側、すなわち、p型電極5側に樹脂をドーム状に形成することにより、LEDの放出光がこのドーム表面で屈折をして方向性に優れた発光を得ることが可能である。また、LEDの周囲に凹面鏡を有するフレームを用いることにより、LEDから横方向に出射した光を凹面鏡で上方向に反射させ、より光取り出し効率の高いLEDを実現することが可能である。もちろん、ドーム状の樹脂と凹面鏡を共用することにより、出射方向制御と光取り出し効率に一層優れたLEDを実現できることは言うまでもない。また、LEDチップをマウントする金属支持体の上で樹脂を硬化させる場合もあるが、ディッピングにより樹脂をモールドして金属支持体を樹脂で取り囲んだ構造も適用できることは言うまでもない。また、紫外線発光

LEDを被覆する樹脂の中に、可視光を発する蛍光材料を含ませたり、樹脂の下面、中間、上面に蛍光材料を含む膜を形成して白色などより発光波長分布の広いLEDを実現することも容易である。さらに、図3(a)に示した実施の形態5の櫛型電極と同様に、オーミック接触部での光吸収を低減する凹凸の多い電極構造が適用できることは言うまでもない。

【0064】

【発明の効果】以上説明したように、本発明によれば、従来、半導体基板と基板裏面側電極との間で生じた光吸収を低減することができるので、光取り出し効率の優れたLEDを実現することができる。

*

*【図面の簡単な説明】

【図1】本発明の実施の形態1～3のLEDの構造を示す側面図である。

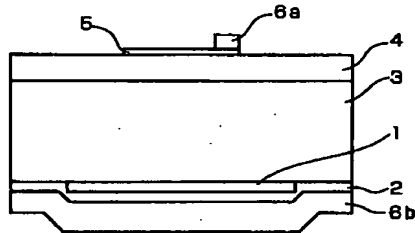
【図2】本発明の実施の形態4のLEDの構造を示す側面図である。

【図3】(a)は本発明の実施の形態5のLEDの構造を示す上面図、(b)は側面図である。

【符号の説明】

1…透明絶縁膜、2…n型電極、3…半導体基板、4…窒化物半導体LED構造、5…p型電極、6a…p型電極（パッド電極）、6b…n型電極。

【図1】



- 1…透明絶縁膜
- 2…n型電極
- 3…半導体基板
- 4…窒化物半導体LED構造
- 5…p型電極
- 6a…p型電極（パッド電極）
- 6b…n型電極

図1

【図2】

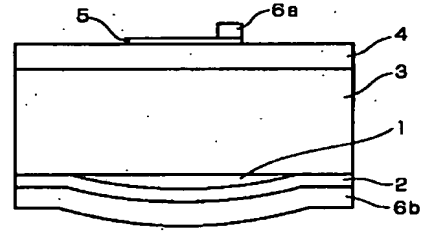


図2

【図3】

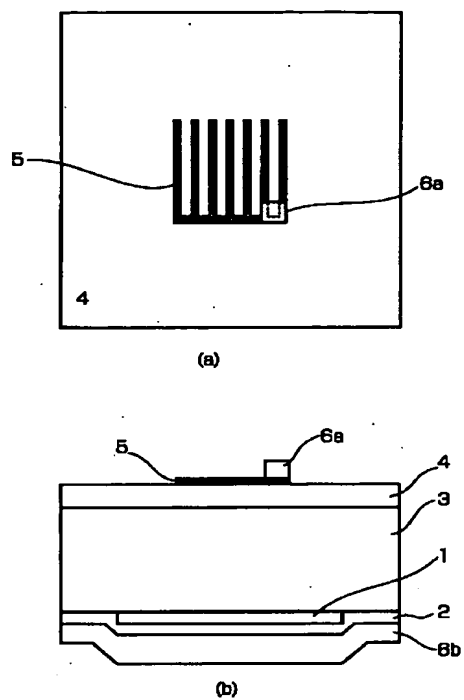


図3

フロントページの続き

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